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**Copolyester Resin for Steel Plate Coatings**

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(54) [Title of the Invention]

Copolyester Resin for Steel Plate Coatings

(57) [Claims]

[Claim 1] A copolyester resin for steel plate coatings, characterized in that the constituent monomers are terephthalic acid, isophthalic acid, and an aliphatic dibasic acid with 4 to 12 carbon atoms, as well as 1,4-cyclohexanedimethanol and neopentyl glycol.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Utilization] The present invention relates to a copolyester resin for steel plate coatings in which terephthalic acid, isophthalic acid, and an aliphatic dibasic acid with 4 to

12 carbon atoms are used as dibasic acid components, and 1,4-cyclohexanedimethanol and neopentyl glycol are used as dihydric alcohol components; and in particular relates to a copolyester resin used with amino resins, applied on steel plates as a baking finish, and able to yield exceptional coated steel plates. The coatings are applied to metallic thin plates such as stainless steel plates, and steel plates that have been cold-rolled, electro-galvanized, and hot dip-galvanized. The aforementioned baking finishes for steel plates are used as coatings suited to coil-shaped coated steel plates (i.e., so-called pre-coated steel plates) that are supplied for use in the forming of products employed in electrical equipment, office and industrial machinery, and household tools; and enable the manufacture of coated steel plates exhibiting an exceptional balance between high hardness and workability, as well as exceptional weather-resistance, chemical-resistance, and other durability-related characteristics. Consequently, the present invention may be employed in the steel plate industry, as well as in electrical equipment, automotive vehicles, conveying machinery, industrial machinery, building materials, and a wide variety of other industries where pre-coated steel plates are utilized.

**[0002]**

**[Prior Art]** Coated steel plates that are supplied in the form of a coil (i.e., so-called pre-coated steel plates) have conventionally been superior to post-coated plates, in which coating is performed after forming, in terms of such aspects as economies of labor and resources realized, environmental safety, and control over the coating process, and such advantages have led to their widespread use. It is common for two coats to be applied to the outer (i.e., obverse) surface of pre-coated steel plates, and one coat to the inner (i.e., reverse) surface thereof. The outer side is treated with a topcoat as the outermost layer, and with an undercoat that prevents against rust and improves adhesion between the topcoat and the steel plate. The inner (reverse) side is commonly treated with a coating that serves to prevent the steel plate from rusting. Coatings used on such pre-coated steel plates are required to have a high degree of workability; e.g., the coatings must be able to be applied at high speeds and baked at high temperature over a short period of time, while exhibiting exceptional resistance to the folding, drawing, and other types of metal forming once applied. The topcoat on the outer surface is also required to exhibit the same degree of glossiness, hardness, stain-resistance, chemical-resistance, and weather-resistance as is obtained from post-coating.

[0003]

**[Problems That the Invention Is Intended to Solve]** No coatings capable of satisfying such mutually incompatible film characteristics yet exist among the coatings that have hitherto been proposed; in particular, there have been no coatings that fulfill the demanding workability requirements called for once the coating process has been completed, and those coatings that have improved workability either exhibit inadequate hardness, stain-resistance, or other characteristics; or are beset with drawbacks related to their poor chemical- resistance, weather-resistance, or the like. Welding cannot be employed for joining such pre-coated steel plates when they have been formed into predetermined products, and therefore crimps, rivets, screws, and other articles are used; however, a less attractive appearance, concentration of stress due to the spot configuration of the joints, and other problems are encountered when such articles are used for joining purposes. The present invention resolves the aforementioned problems associated with the prior art, and is intended to enable the manufacture of a coated steel plate that exhibits an exceptional balance between a high degree of workability and hardness, stain-resistance, chemical-resistance, and weather-resistance, while also exhibiting good post-forming structural adhesiveness.

[0004]

**[Means Used to Solve the Above-Mentioned Problems]** As a result of diligent studies performed in response to the aforementioned problems, the present inventors perfected the present invention as a result of developing a resin that is exceptional as a starting material for a steel plate coating, and as a result of discovering that the aforementioned problems could be resolved by employing this resin. In other words, the present invention relates to a copolyester resin for steel plate coatings characterized in that the constituent monomers are terephthalic acid, isophthalic acid, and an aliphatic dibasic acid with 4 to 12 carbon atoms, as well as 1,4-cyclohexanedimethanol and neopentyl glycol.

[0005] The present invention is described in further detail hereunder.

(Copolyester resin)

The essential structural monomer components in the copolyester resin used in the present invention are the dibasic acid components terephthalic acid, isophthalic acid, and an aliphatic dibasic acid with 4 to 12 carbon atoms; and the dihydric alcohol components 1,4-cyclohexane dimethanol and neopentyl glycol. Specific examples of aliphatic dibasic acids with 4 to 12

carbon atoms include succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecylenic acid, dodecane diacid, and other aliphatic dibasic acids; as well as ester derivatives thereof.

[0006] The ratio in which these dibasic acid components are used, based on the total amount of dibasic acid components used, is preferably 20 to 60 mol% of terephthalic acid, 5 to 45 mol% of isophthalic acid, and 10 to 60 mol% of aliphatic dibasic acids having 4 to 12 carbon atoms. When less than 20 mol% of terephthalic acid is present, the cohesive force of the resin will be inadequate, and the coating film will be lacking in hardness; conversely, when more than 60 mol% is present, the resin will become hard, and the workability of the coating film will deteriorate. When less than 5 mol% of isophthalic acid is present, the glossiness of the coating film will deteriorate; conversely, when more than 40 mol%\* is present, the resin will become brittle, and the coating film will suffer from diminished workability and poor weather-resistance. When less than 10 mol% of the aliphatic dibasic acid component is present, the resin will harden, and the workability of the coating film will deteriorate; conversely, when more than 60 mol% is present, the resin will become flexible, the degree of hardness will decrease, and the chemical-resistance will deteriorate. Examples of acid components in the copolyester resin other than those mentioned in the foregoing include orthophthalic acid,  $\alpha$ -naphthalenedicarboxylic acid,  $\beta$ -naphthalenedicarboxylic acid, and other aromatic dibasic acids; and 1,4-cyclohexane dicarboxylic acid, tetrahydrophthalic anhydride, hexahydrophthalic anhydride, and other alicyclic dibasic acids, which may be additionally used provided that the amount does not cause the characteristics of the composition of the present invention to be sacrificed. It is also possible to jointly use trimellitic acid, pyromellitic acid, and other polycarboxylic acids, provided that the amount does not cause the coating film performance or gelling during the reaction to be sacrificed. When a polycarboxylic acid is jointly used, the amount thereof is preferably 5 mol% or less with regard to the total acid component.

[0007] The essential dihydric alcohol components that constitute the copolyester resin of the present invention are 1,4-cyclohexanedimethanol and neopentyl glycol. The ratios in which these dihydric alcohol components are used are preferably 5 to 40 mol% of 1,4-cyclohexane dimethanol and 20 to 70 mol% of neopentyl glycol, based on the total amount of dihydric alcohol components used. When less than 5 mol% of 1,4-cyclohexanedimethanol is present, the

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\* [Translator's note: the range specified earlier in this paragraph cites an upper limit of 45 mol%, not 40.]

weather- and chemical-resistance of the coating film will be inadequate; conversely, when more than 40 mol% is present, the resin will become hard, and the coating film will become unworkable. When less than 20 mol% of neopentyl glycol is present, the hardness of the coating film will be inadequate; conversely, when more than 70 mol% is present, the coating film will become hard, and its workability will deteriorate. Other dihydric alcohol components may additionally be used as the alcohol components for the copolyester resin, with specific examples including ethylene glycol, 1,2-propyleneglycol, 1,4-butanediol, 1,3-butanediol, 1,5-pentanediol, neopentyl glycol, 1,6-hexanediol, 3-methylpentanediol, 2,2,3-trimethylpentanediol, diethylene glycol, triethylene glycol, dipropylene glycol, and other aliphatic dihydric alcohols. Glycerin, trimethylol ethane, trimethylol propane, pentaerythritol, and other polyhydric alcohols may also be jointly used in a manner similar to that employed with the acid components. When jointly using these polyhydric alcohols, the amount thereof is preferably 5 mol% or less with regard to the total alcohol component. It is preferable for ethylene glycol to be jointly used as a dihydric alcohol alternative to 1,4-cyclohexanedimethanol and neopentyl glycol; its use increases the cohesive force of the resin and enables the coating film to be endowed with a suitable level of hardness and heightened durability.

[0008] The number-average molecular weight of the copolyester resin of the present invention is preferably 10,000 to 30,000 (in terms of GPC, PSt), and more preferably 12,000 to 25,000. If the molecular weight falls below this range, diminished workability or the like will result when the coating film is fabricated; conversely, if the molecular weight exceeds this range, problems will be presented when the coating is applied due to the excessively high viscosity encountered when the resin is dissolved in a solvent.

[0009] The copolyester resin of the present invention is manufactured using a common method. Suitable examples of such methods include melt-polymerization, in which the starting materials (i.e., equimolar amounts of the acid and alcohol components) are heated at a temperature that is the same or higher than the melting point of the product; solid-state polymerization, in which polymerization is performed at or below the melting point of the product; and solution polymerization, in which a solvent is employed. Although all of these methods may be utilized, melt-polymerization is preferred because of economic considerations, and because a polyester having a degree of polymerization suitable for the object of the present invention may be

efficiently produced thereby; the resin may also be manufactured by means of transesterification and direct esterification.

**[0010] (Amino resins)**

The copolyester resin of the present invention is jointly used with amino resins as is common with other coating resins, and is used as a baking finish for steel plates. Examples of amino resins that are jointly used include thermosetting resins, which are obtained by means of subjecting formaldehyde to a reaction with melamine, benzoguanamine, urea, or the like; and resins in which all or a part of the methylol groups in a thermosetting resin obtained by means of such a reaction have been converted to methyl, butyl, or another alkyl ether. Among amino resins, melamine resins in which the melamine has been methylolated are preferred with regard to their exceptional balance between workability and hardness after coating film formation; specific and preferred examples thereof include methylated melamine, *i*-butylated melamine, and *n*-butylated melamine. These amino resins may be used singly or in combinations of two or more. The (weight) ratio of the copolyester resin to the amino resin is preferably 90/10 to 60/40, and more preferably 85/15 to 65/45. A lower amino acid content will result in low crosslinking density, hardness and durability, and diminished adhesive strength; conversely, a higher content will result in an unreacted amino resin and disadvantageous durability.

**[0011] (Coating preparation method)**

The baking finish for steel plates in which the copolyester resin of the present invention is used is manufactured by means of compounding and dissolving in a solvent, first, a pigment selected in accordance with the amino resins and the desired application, and, second, a suitable additive that is commonly employed in the production of coatings in order to improve the durability of the coating and to prevent adverse situations from occurring when the coatings are applied or their characteristics adjusted. Examples of such pigments include titanium dioxide, white lead, chrome yellow, minium, strontium chromate, zinc chromate, titanium yellow, cadmium yellow, black titanium oxide, black iron oxide, molybdate orange, molybdenum white, Berlin blue, ultramarine blue, talc, mica, barium sulfate, calcium carbonate, silica, and other inorganic pigments; and carbon black, soluble and insoluble azo dyes, phthalocyanine systems, and other organic pigments. Examples of additives include viscosifiers, pigment dispersants, defoamers, antiskinning agents, leveling agents, slicking agents, lubricants, curing promoters, antioxidants, UV absorbers, hydrolysis inhibitors, and other products that are extensively and

advantageously used in the relevant fields. The solvent is selected in consideration of the viscosity of the final coating product, with specific examples of solvents including toluene, xylene, tetralin, mixed petroleum-based C<sub>9</sub> to C<sub>11</sub> solvents, and other aromatic solvents; methyl ethyl ketone, methyl isobutyl ketone, diisopropyl ketone, dibutyl ketone, cyclohexanone, isophorone, and other ketone-based solvents; butanol, ethylene glycol methyl ether, ethylene glycol ethyl ether, ethylene glycol butyl ether, propylene glycol methyl ether, propylene glycol ethyl ether, propylene glycol butyl ether, 3-methoxybutanol, 3-methyl-3-methoxybutanol, and other alcohol-based solvents; and ethyl acetate, propyl acetate, butyl acetate, ethylene glycol methyl ether acetate, ethylene glycol ethyl ether acetate, ethylene glycol butyl ether acetate, propylene glycol methyl ether acetate, propylene glycol ethyl ether acetate, propylene glycol butyl ether acetate, dimethyl adipate, dimethyl glutarate, dimethyl succinate, 3-methoxybutylacetate, 3-ethoxypropionate, and other ester-based solvents. Solvents selected from among those cited hereinabove may be used singly or in mixtures of two or more.

**[0012] (Steel plate)**

Examples of steel plates on which the coating obtained as described in the foregoing may be applied include stainless steel plates; cold-rolled, electro-galvanized, hot-dip galvanized, alloyed hot-dip galvanized, electro-galvanized nickel alloy-plated, electro-tinned, and aluminum-plated steel plates; and those obtained by means of subjecting the aforementioned steel plates to a chromate or phosphate treatment. Steel plates that have been subjected to an organic thin film treatment after having been chemically treated as described in the foregoing may also be employed.

**[0013] (Coating method)**

Methods for applying coatings to steel plates are well known in the art; once a coating has been adjusted to an appropriate coating viscosity, the plates may be coated by means of selecting a method such as roll-coating, flow-coating, or spray-coating. The plates are coated at a rate of 30 to 120 m/min, and are subjected to hot-blast heating, far-infrared heating, high-frequency induction heating, or other stoving method when passed through a furnace. The coating film thickness is 3 to 50  $\mu\text{m}$ , and preferably 15 to 25  $\mu\text{m}$ ; the baking temperature is preferably adjusted so that the plate temperature reaches 120 to 300°C, and preferably 150 to 270°C; and baking is performed for 15 to 80 sec. It is desirable for an undercoat to be applied to the steel plate before the coating is applied thereto, in consideration of the durability of the



coating film, corrosion-resistance, and the plate-coating adhesion. A polyester, epoxy, or modified epoxy coating or the like is ordinarily used for the undercoat, and is applied to a dry thickness of 1 to 10  $\mu\text{m}$ , and preferably 3 to 7  $\mu\text{m}$ . There are also circumstances where the coating is applied not only to one surface, but to both, in which case the reverse surface is ordinarily coated with an epoxy or modified epoxy coating or the like for purposes of preventing against rust and utilizing the adhesive characteristics inherent therein.

**[0014] (Bonding method)**

Pre-coated steel plates coated with the baking finish for steel plates that uses the copolyester resin of the present invention are especially suited to bonding processes in which a variety of bonding agents are employed. The bonding agent may be selected from among urethane-, epoxy-, polyester-, polyamide-, acrylic-, and cyanoacrylate-based versions. An adhesive tape, a pressure-sensitive adhesive based on an acrylic, rubber, or other system, or another type of adhesive may also be used as required. It is appropriate for coated steel plates that have been bonded together in such a manner to be able to exhibit a T-peel adhesive strength of 15 kg/25 mm or greater when taking into account the circumstances in which they will ultimately be applied, and the bonding agent should be selected in consideration of this fact. Polyester- and urethane-based bonding agents are preferred among those described in the foregoing due to their manageability when applied, ability to bond in short periods of time, adhesive strength, and durability. Polyester-based bonding agents are so-called hot-melt bonding agents in which a copolyester is used as a principal component, with preferred examples being those that contain a copolyester wherein terephthalic acid comprises 20 mol% or more of the acid starting material component. It is also possible to use bonding agents in which the copolyester resin has been compounded with a variety of additives that impart adhesiveness, flowability, and other characteristics. The bonding agent may be melt-coated using an applicator or the like; or used in the form of a film, web, powder, solution, or other configuration, when applied in actual use. Two-liquid-type urethane-based bonding agents comprising polyol and isocyanate components able to be applied in liquid form are preferred from the perspectives of curability and adhesive strength. Bonding is performed with the aforementioned bonding agents when using pre-coated steel plates on which the coating has been applied either to one or both sides thereof, by means of laying one of the surfaces on which a prescribed coating film has been formed over the other, or, in cases where the selected bonding agent is able to be utilized on a

surface on which a prescribed coating film has not been formed, laying that surface over a surface on which a prescribed coating film has been formed. Possible bonding means include a method in which the coated steel plates and bonding agent are heated while being compressed under pressure, and a method in which high-frequency induction is used to heat the locations in which the coated steel plates have been bonded, and a cooled hammer is used immediately afterwards to cool the plates in a short period of time.

**[0015] (Applications)**

Pre-coated steel plates coated with the baking finish for steel plates that uses the copolyester resin of the present invention exhibit exceptional coating film performance and durability, as well as excellent adhesiveness. Consequently, these steel plates may be used in refrigerators, washing machines, microwave ovens, air-conditioning equipment, fluorescent lamps, stoves, audio equipment, freezer showcases, automatic vending machines, and other electrical appliances; office desks, shelving units for document storage, partitions, and other office products; and in other applications.

**[0016]**

**[Operation]** The following is presumed to be the reason for the excellent performance exhibited by steel plates that have been treated with the baking finish in which the copolyester resin of the present invention is used. The hindrance effect of the cyclohexane rings with the bulky ester bond moieties of 1,4-cyclohexanedimethanol mitigates the hydrolysis-induced degradation of coating films that is typical of polyesters; exceptional chemical-, water-, humidity- and weather-resistance is displayed; and the coating film itself is imparted with a suitable degree of flexibility, and exhibits balanced hardness and moldability.

**[0017]** The present invention is described below with reference to specific examples.

**[Working Examples]**

**Working Example 1**

77.6 parts by weight of dimethyl terephthalate, 74.4 parts by weight of ethylene glycol, 62.5 parts by weight of neopentyl glycol, 28.8 parts by weight of 1,4-cyclohexanedimethanol, and 0.05 parts by weight of zinc acetate were charged into a four-neck flask equipped with a stirrer, nitrogen-introduction tube, distilling tube, and temperature gauge. The temperature was elevated as nitrogen was introduced into the flask, and methanol was used to distill the mixture at

150 to 200°C. 33.2 parts by weight of isophthalic acid, 58.4 parts by weight of adipic acid, and 0.05 parts by weight of antimony trioxide were additionally charged thereinto, and water was used to distill the mixture at 200 to 240°C. Polyester resin (A) was obtained as a result of continuing the reaction under a reduced pressure of 1 mmHg at 240°C for 3 hours while the pressure was gradually reduced. The resulting polyester resin (A) was a transparent light-yellow solid; its number-average molecular weight was 12,000; and the composition of the polyester as determined by means of NMR analysis revealed an acid component comprising terephthalic acid, isophthalic acid, and adipic acid in a molar ratio of 40/20/40, and a dihydric alcohol component comprising ethylene glycol, neopentyl glycol, and 1,4-cyclohexanedimethanol in a molar ratio of 39/41/20.

**[0018] Working Examples 2 through 7, and Comparative Examples 1 through 5**

Copolyesters (B) through (L) having the polyester compositions displayed in Table 1 were synthesized according to the same method employed for Working Example 1. (F) through (J) are comparative examples.

[0019]

[Table 1]

	A	B	C	D	E	F	G	H	I	J	K	L
TPA	40	55	55	25	20	40	40	50	60		40	40
IPA	20	30	10	20	40	20	20	50		60	20	20
SuA				55								
AdA	40		35		40	40	40		40	40	40	38
SbA		15										
TA												2
NPG	41	60	27	52	26	55		51	42	40	40	40
CHDM	20	10	41	48	21		52	49	30	41	20	18
EG	39	30			53	45	48		28		37	42
HD			32							19		
TMP											3	
Appearance of liquid*	A	A	B	A	A	B	A	A	C	A	A	A
Mn	12000	18000	19000	21000	15500	17500	20000	15000	18000	16000	19500	22000

Note: the symbols appearing in the table designate the following compounds.

TPA: terephthalic acid, IPA: isophthalic acid, SuA: succinic acid, AdA: adipic acid, SbA: sebacic acid, TA: trimellitic anhydride, NPG: neopentyl glycol, EG: ethylene glycol, CHDM: 1,4-cyclohexanedimethanol, HD: 1,6-hexanediol, and TMP: trimethylol propane

### [0020] Evaluation Test Example 1

70 parts of polyester resin (A) was dissolved in 100 parts of a mixed solvent comprising xylene and cyclohexanone in a ratio of 1/1 (weight ratio), and 100 parts of titanium oxide (Tipaque CR-50; manufactured by ISK Co., Ltd.) was compounded with the resulting solution. After the solution had been stirred at high speed, glass beads were added thereto, and the mixture was shaken with a paint shaker for five hours. 30 parts of amino resin (Uban 122; 60% nonvolatile content; manufactured by Mitsui Toatsu Chemicals, Inc.) and 0.05 parts of *p*-toluenesulfonic acid were blended therewith, and the resulting mixture was adjusted with the aforementioned mixed solvent until the non-volatile content reached 50%, yielding a baking finish for steel plates. The coating was applied on a degreased electro-galvanized chromate-treated steel plate (0.5 mm thick) to a dry thin film thickness of 20  $\mu$ m using a bar coater, and the coated plate was placed in a hot-air heating furnace for 60 sec until the plate had reached a temperature of 240°C. The plate was cooled and then subjected to the following tests.

\* [Translator's note: the criteria that apply to the levels of appearance are not described in the text. Accordingly, a range of "A" through "C" has been provided, with "A" towards the "better" end, and "C" towards the "worse" end]

(1) Glossiness

Glossiness was measured at 60° according to JIS K5400 7.6.

(2) Pencil hardness

Pencil hardness abrasion was evaluated according to JIS K5400 8.4.2.

(3) Foldability

Cracking and peeling of the coating film were judged after the plate was bent into a cylinder and secured in a vise, according to JIS K5400 8.1.

(4) Stain-resistance

Indelible ink pens (blue, black, and red) were used to draw lines 20 mm long on the surface of the coated film, which was then left to stand for 24 hrs in a thermostatic chamber (23°C, 60% RH), before the ink was wiped off with an ethanol-impregnated cloth. Observations were made of the markings that remained.

(5) Acid-resistance

The plate was immersed in an aqueous 5% sulfuric acid solution for 24 hrs at 20°C, and the acid-resistance was expressed in terms of the gloss retention (%) relative to the pre-immersion value.

(6) Alkali-resistance

The plate was immersed in an aqueous 5% sodium hydroxide solution for 24 hrs at 20°C, and the alkali-resistance was expressed in terms of the gloss retention (%) relative to the pre-immersion value.

(7) Weather-resistance

A test was performed according to ASTM-G53 under UV irradiation at 60°C for 4 hrs and exposure to moisture at 40°C for 4 hrs, and the weather-resistance was expressed in terms of the gloss retention (%) after 480 hrs of exposure relative to the pre-immersion value (60 degrees).

(8) Adhesiveness

The coated steel plate was cut into 25 mm (width) × 100 mm (length) pieces, a 100-μm polyester-based bonding agent was inserted between the coated surfaces of the plates, and the assembly was bonded together with the aid of a heat press under applied pressure (5 kg/cm<sup>2</sup>) at 150°C for 2 min. The T-peel adhesive strength (kg/25mm) of the bonded article was measured at a crosshead speed of 200 mm/min.

### [0021] Evaluation Test Examples 2 through 8

Evaluation tests were performed by means of fabricating coated steel plates according to the same method employed in Evaluation Test Example 1 using polyester resins B through E, K, and L, and adjusting the coatings according to the compositions displayed in Table 2. The results are shown in Table 2.

### Comparative Evaluation Test Examples 1 through 5

Evaluation tests were performed by means of fabricating coated steel plates according to the same method employed in Evaluation Test Example 1 using polyester resins F through J, and adjusting the coatings according to the compositions displayed in Table 2. The results are shown in Table 2.

[0022]

[Table 2]

	Evaluation test examples								Comparative evaluation test examples				
	1	2	3	4	5	6	7	8	1	2	3	4	5
Polyester (type)	A	B	C	D	E	K	L	L	F	G	H	I	J
(amount)	70	85	80	75	70	65	80	90	70	75	80	70	85
Amino acid (type)	M-1	M-1	M-1	M-1	M-2	M-3	M-1	M-1	M-1	M-1	M-2	M-2	M-2
(amount)	30	15	20	25	30	35	20	10	30	25	20	30	15
Titanium oxide (amount)	100	100	100	100	100	100	100	100	100	100	100	100	100
Glossiness	85	83	84	80	85	82	79	80	85	80	81	83	79
Pencil hardness	2H	2H	F	H	H	H	H	F	H	F	3H	H	HB
Folding workability	0T	0T	0T	0T	0T	1T	1T	0T	0T	2T	8T	2T	2T
Stain-resistance* (blue)	A	A	A	A	A	A	A	A	A	A	A	A	B
(black)	B	B	B	B	B	B	B	B	B	C	B	B	C
(red)	C	B-C	B-C	B-C	B	C	C	C	C	D	B	C	D
Alkali-resistance	85	90	99	97	95	96	93	92	50	95	95	92	70
Acid-resistance	98	102	100	102	99	100	97	99	95	100	97	103	88
Weather-resistance	70	87	88	86	80	83	75	71	45	50	40	71	43
Adhesiveness	20	18	19	22	20	19	22	21	17	20	18	12	15

Note: The following commercial amino acids were used.

M-1: Uban 122 (*n*-butylated melamine resin; 60% nonvolatile content; Mitsui Toatsu Chemicals, Inc.)

M-2: Superbeckamine L-145-60 (*i*-butylated melamine resin; 60% nonvolatile content; Dainippon Ink & Chemicals, Inc.)

M-3: Cymel 303 (methylated melamine resin; 100% nonvolatile content; Mitsui-Cyanamid K.K.)

\* [Translator's note: the criteria that apply to the levels of appearance are not described in the text. Accordingly, a range of "A" through "D" has been provided, with "A" towards the "better" end, and "D" towards the "worse" end.]

**[0023]**

[Effect of the Invention] The steel plate coated with the baking finish using the copolyester resin of the present invention has a coating performance that exhibits such mutually incompatible attributes as hardness, stain-resistance, and workability; and has exceptional chemical-resistance and weather-resistance. A method wherein bonding is performed with a variety of bonding agents once the plate has been drawn, folded, or otherwise formed may be substituted for conventional non-welding mechanical joining methods such as screw-fixing, seaming, and crimping; and offers an innovative development as relates to the appearance and design of the formed and joined plates. The coated steel plate may be used extensively and advantageously in electrical and office equipment, building materials, transport vehicles, and the like.